Harnessing Wind, Water, and Sun.

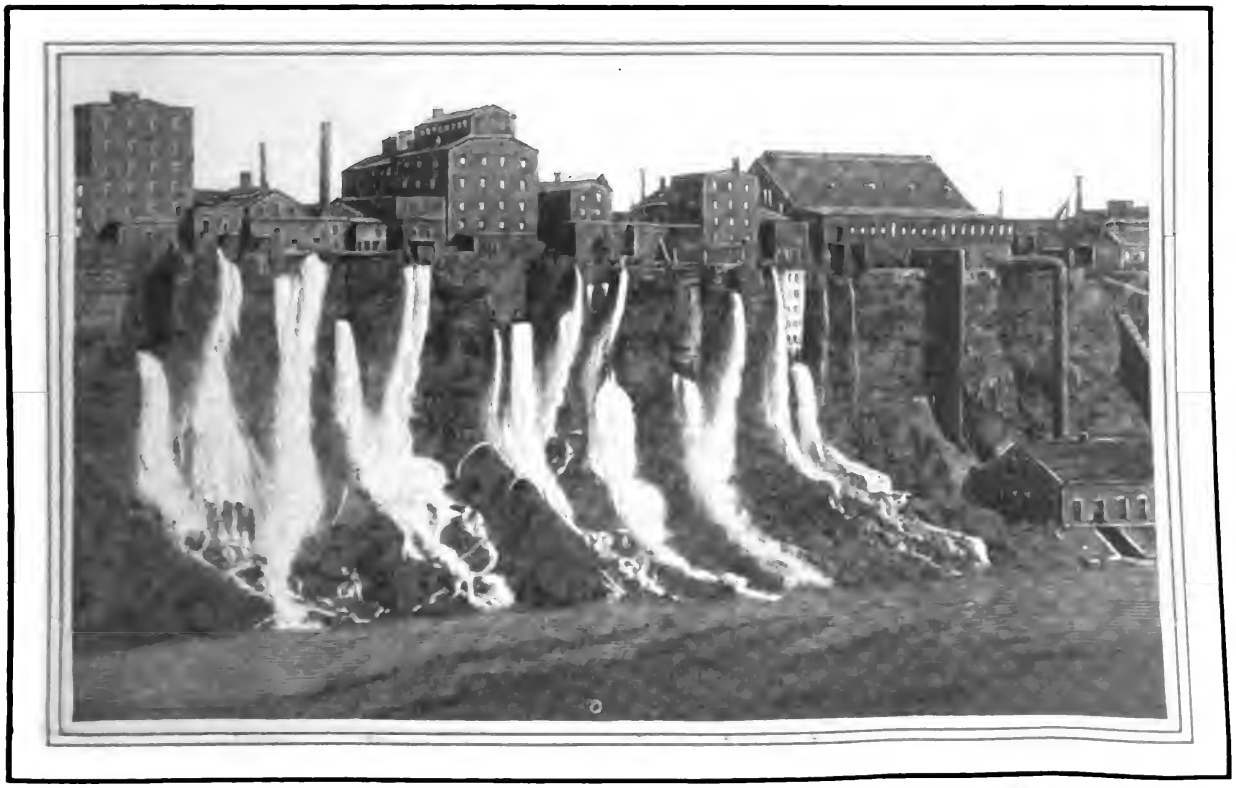
BY GEORGE B. WALDRON.

HOW SCIENCE IS HARNESSING NATURE'S MIGHTIEST FORCES—INVENTIONS AND EXPERIMENTS THAT GO FAR TOWARD ANSWERING THE QUESTION WHAT WE SHALL DO WHEN ALL THE WORLD'S SUPPLY OF COAL IS BURNED.

WHAT will the world do when the coal is gone? It is a query frequently propounded, and eager scientists have discussed and argued the matter with earnest enthusiasm. They have estimated that we burn about eight hundred million tons of coal a year, and that at the present rate of consumption, there is enough in the world's known deposits to last a thousand years, and no more. Hence their anxiety.

It is reasonably certain that long before coal becomes so expensive that it cannot be widely used, we shall have succeeded in doing without coal to a large extent, for already great strides have been made in making nature's forces work for us. Sun, wind, and water, the perpetual energies, are in harness. In one form or another they have long been under control, in so far as man was able to make use of them. The idea of taking advantage of favoring winds to help a ship along its course is thousands of years old. It took many generations to develop a way to set sails so as to utilize winds from every direction. The discovery of a way to run a vessel into the teeth of the wind by the wind's own power was a great triumph.

And on land as well man learned to make use of wind power. Through all the ages the windmill has continued in service, and has grown in numbers and



A ROW OF FACTORIES ON THE BLUFF BELOW NIAGARA FALLS, OPERATED BY WATER POWER FROM THE RIVER.

in power. There are doubtless more such devices at work today than there ever have been. The pioneer of two hundred years ago set up his windmill to grind his flour. On Rhode Island—the island proper, not the State—I have sat down to the famous "Johnny cake" of the district, and one of the essential elements of that appetizing dish was the fact that the corn was ground in the great windmill whose white sails I could see cutting the air. The visitor at Newport would be amply repaid to make a trip of six or seven miles across the island to see the half dozen mills yet serving its inhabitants' wants.

POWER FROM THE PRAIRIE WINDS.

Holland is known the world over as a country of windmills, and they bring her much of her prosperity. In our own land the same is coming to be true in the Nebraska country. In the Platte Valley, particularly, is a broad, rich land with abundant water a few feet below the surface, but too deep below to nourish its crops, and there is almost no rain. Through the valley sweeps a strong wind with scarcely a break for nine days out of ten, and the shrewd farmer has harnessed the wind to his pumps, and is growing rich.

These Nebraska farmers do not spend hundreds of dollars in setting up mills turned out of Eastern factories. They put together old boards, old nails, old tin cans, old iron, anything that will serve the purpose. At the cost of a little labor and of a very few dollars in cash, they have a windmill that will draw water for the stock, or for home use, supply the gardens and even the fields, cut the feed, shell and grind the corn, turn the grindstone and the churn—in short, do a hundred things for them without cost.

A favorite form is the "little Jumbo." It looks like a big dry goods box open at the top, with a revolving fan half covered by the sides. The shaft of the wheel is horizontal, and rests at either end on the box edge. The wind catches the sails above, while the sides of the

THE INTERIOR OF THE ROOM WHEREIN NIAGARA'S POWER IS HARNESSED, THE GREATEST POWER PLANT IN THE WORLD. THE TOP OF THE SHAFT ATTACHED TO EACH WATER WHEEL AND DYNAMO CAN BE PLAINLY SEEN.

box protect those below. It is the simplest kind of an arrangement, but it accomplishes a marvelous amount of work. One that cost less than four dollars, and is only three feet long, pumps five or six hundred gallons of water in an hour, supplying water for all the farmer's stock, and for a boarding house of thirty people.

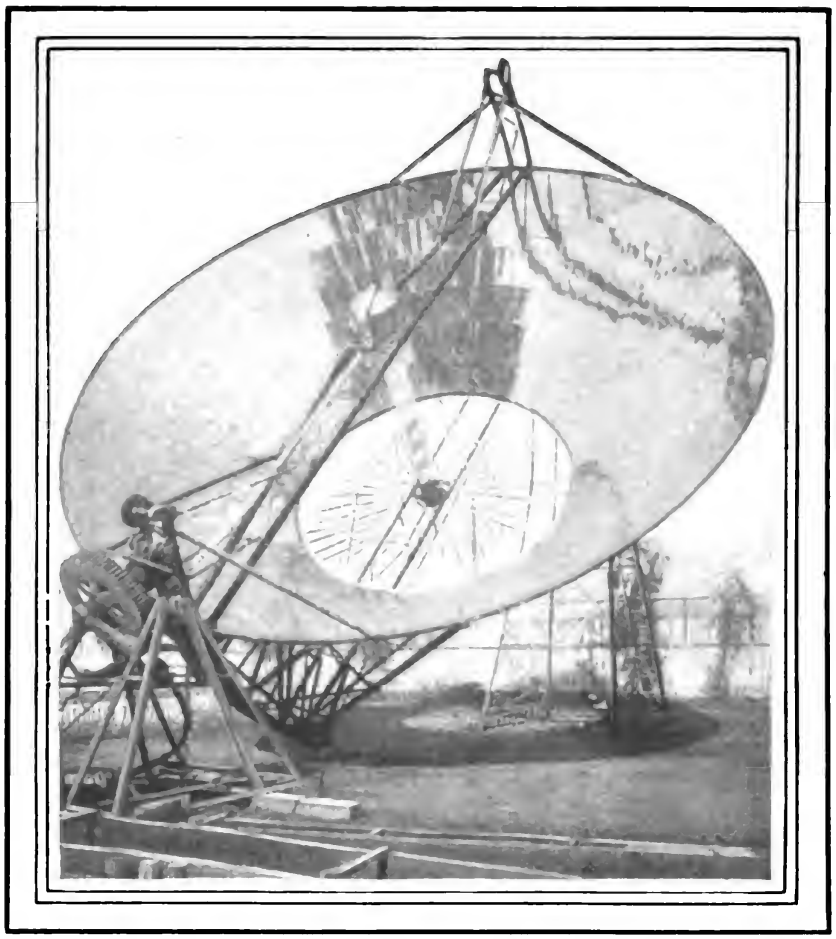
The "little Jumbo" refuses to work when the wind is in certain directions; but in the Platte Valley the winds blow north and south for nine tenths of the time, so this objection is of comparatively small importance. Some farmers build another "little Jumbo" to run with an east and west wind, and so derive advantage from every breeze. Another plan is to turn the shaft of the wheel in a vertical direction, and, by means of doors that are regulated according to the direction of the wind, to shut it off from half the wheel. These are called "merrygorounds." Some are very large, and as the sails chase one another around the circular track, at a little distance one could easily imagine himself watching a revolving group of children at the seashore or on the picnic grounds. There are other and more intricate styles of home made mills, such as the "battle ax" and the "turbine," but all serve the same purposes. For five hundred miles west of Omaha, the traveler is never out of sight of one of them.

THE OLD FASHIONED WINDMILL FOR GRINDING GRAIN, ONE OF THE MOST ANCIENT OF ALL DEVICES FOR UTILIZING NATURE'S FORCES.

Many efforts have been made to turn the winds to account on a broader scale. Perhaps the most ambitious is that of Gustave Couz, at Hamburg, Germany. He has built a wind wheel forty feet in diameter, with a sail surface of more than a thousand square feet. It is automatically regulated to eleven revolutions a second, and develops from one to thirty horse power, according to the strength of the wind. The wheel is harnessed to a dynamo, and the electricity produced is carried to a storage battery, to be drawn off as needed. This battery overcomes the unsteady action of the wind, and produces an even flow for electric lamps.

STREAMS THAT TURN WHEELS.

Another natural source of power, one of almost unlimited possibilities, is the waterfall and the running stream. Our grandfathers harnessed the brooks to grind their flour. With the coming of steam and the great mills of the West, conditions have vastly changed. "The mill has gone to decay, Ben Bolt," and the streams no longer turn the grind-



THE SOLAR MOTOR IN OPERATION AT SOUTH PASADENA, CALIFORNIA—A FRONT VIEW, SHOWING THE REFLECTOR, THE BOILER, AND THE GEARING THAT REVOLVES THEM.

stones; but we are coming back to the old idea with new modifications.

In a Vermont town, three or four years ago, I found to my astonishment that nearly every house was lighted by electricity. The power came from a mountain brook four or five miles away. It is a practical illustration of the coming evolution. We have grown used to the idea of a mammoth power plant at Niagara supplying light and power to Buffalo and the neighboring cities, while the water continues to run over the rocks in apparently undiminished volume. The power will be trebled by additional plants now building, and yet other works may be added until the rocks go bare. It is only a question of transmitting the power after it has been made. With today's knowledge, Niagara's power can be sent to New York, nearly five hundred miles away. But all the power is needed in the Niagara region. In California, however, they are lighting San Francisco with power carried a hundred and fifty miles.

At the "Soo" it will not be many years before every drop of water now allowed to run over the picturesque rapids from Lake Superior will pay toll to man's needs. A plant of sixty thousand horse power, ten thousand more than the big Niagara plant now yields, is almost completed, and another on the opposite side of the river is building.

THE MIGHTY POWER OF THE TIDES.

Should there be need for more power when all the streams of the world are harnessed, it is not far to seek. Twice a day on the ocean shores the tides rise and fall. Always under the wind's lashing, the waves roll upon the beach. The man who learns to use the enormous, resistless power of tide and wave will transform much of the present activities of the world.

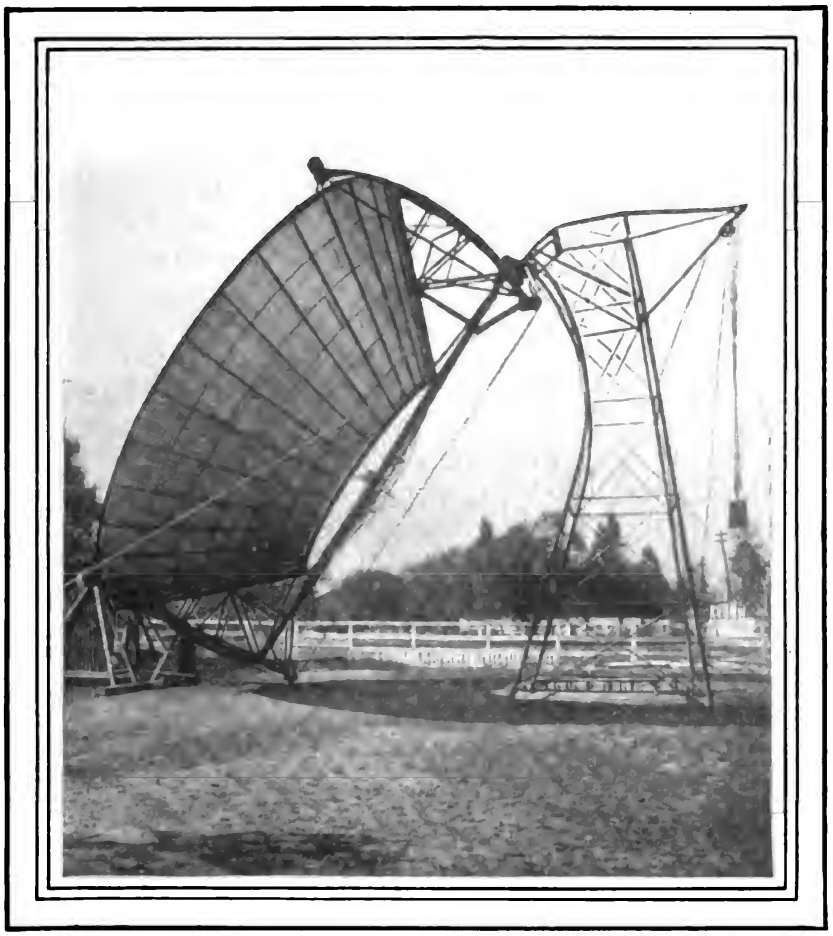
Something has already been done in this direction. In Brooklyn there yet stand three mills more than a hundred years old, whose wheels were once turned by the rise and fall of the tides. The plan is simple. Across the mouth of a creek emptying into Jamaica Bay a dam with a sluice gate was built. As the tide rose, the water accumulated behind the dam till the gate was closed, just before the ebb. After the tide had fallen, the imprisoned water passed swiftly down a short sluiceway to the sea, turning as it went a large undershot wheel. One of these mills is said to be still in working order, and to serve the farmers of the neighborhood.

An Englishman, Morley Fletcher, has invented a machine that takes power direct from the waves. It is like an inverted pump, with the piston securely anchored in a perpendicular position to

the sea bottom. Over the piston moves a cylinder attached to a hollow, cheese shaped float, which rides upon the water and moves the cylinder up and down upon the piston with every rise and fall of the waves. The apparatus has been used successfully in blowing fog horns off a dangerous coast.

More pretentious is a wave motor built at Potencia Beach, California, in January, 1897. At the end of an iron wharf extending about three hundred and fifty feet into the ocean were placed three floats, each ten feet square. These are permitted to move only in a vertical plane, and are loaded so as to be considerably heavier than the water. The side of the float towards the incoming wave is inclined thirty degrees, to make use of the lifting power of the water. Attached to the float is a piston which works in a cylinder, and by its weight, in descending, forces air into a chamber on shore. The air force in this chamber, in turn, is applied to a column of water, which is directed under several hundred pounds' pressure against the edges of a water wheel. The water falls from the wheel, again to be pumped up into the chamber and renew its journey; but the power it carries is taken on a dynamo, which keeps in service a series of electric lights. Such an installation will develop from two to three horse power for each float.

It is estimated that a thousand horse power machine of this pattern, capable of supplying ten thousand incandescent lamps, could be built for a little more than a hundred thousand dollars. The cost of running is estimated at only thirteen dollars a year per horse power, including interest on the investment, which is a small part of the ordinary cost of steam.



THE SOUTH PASADENA SOLAR MOTOR—A SIDE VIEW OF THE REFLECTOR AND THE MECHANISM THAT SUPPORTS IT AS IT REVOLVES, ALWAYS FACING THE SUN.

THE MIGHTIEST RESERVOIR OF POWER.

But why stop with wind and water power? Why not go to the vast, the incalculable reservoir of force which not only put these in motion, but from which came the imprisoned power of coal itself—the sun? So powerful are the sun's rays, when at their height, that on every square yard of the earth's surface there falls the equivalent of three horse power. The sunshine on a four acre lot at noonday represents an energy equal to that now taken from Niagara. Enough heat falls on a steamship's deck, if it were all gathered up and applied to the propeller, to drive the vessel along at its usual speed. The world uses eight hundred million tons of coal every year and wastes nine tenths of it in the using, while upon an area less than twenty miles square of the Sahara desert the sun is pouring as much heat as that coal contains.

For thousands of years inventors have sought how to put this enormous power to use. The schoolboy hears the story of Archimedes, how twenty years before Christ he set on fire the ships of the enemy in the harbor of Syracuse by concentrating on them the heat of scores of mirrors. John Ericsson, the builder of the Monitor, turned his attention to the problem, and in 1870 produced his first solar machine. Then for fourteen years he labored to perfect his motor. The best he could do was to produce about one horse power from a surface of a hundred square feet, thus using only a thirtieth of the actual energy of the sun. His method was to condense the heat upon a boiler of water by mirrors.

About the same time, a Frenchman, Mouchot, produced similar results. The latter afterwards put his discoveries to practical use by building a machine light enough to be carried on a man's back. It is useful for distilling water on the ocean or in arid regions, and will distil two and a half quarts in an hour. The French have put this method of distilling to use in Algiers on an extensive scale.

We do not need to go to the Sahara to find desert. The arid plains of our own great West are a needy field. There the sun shines with scarcely a cloud. Given a cheap power to pump the water, these barren plains would "blossom like the rose," and the power is there in limitless abundance, if only it can be used.

AN OVERSHOT WHEEL, SUPPLIED WITH WATER BY A DAM IN A STREAM —ANOTHER ANCIENT DEVICE FOR HARNESSING NATURAL POWER.

THE SUN MOTOR AT PASADENA.

In southern California, at South Pasadena, an experiment is now in progress that holds out a hope of redemption to the whole of that great Western country. It is a solar motor built on the same general principle followed by Ericsson, but brought to a perfection that seems to promise practical usefulness. The essential part of the motor is a huge glass reflector, somewhat the shape of an umbrella with its top cut off. The inner surface is lined with one thousand seven hundred and eighty eight small mirrors, so arranged that they reflect the sunlight upon a boiler located at the center, corresponding to the handle of the umbrella. The great disk is circular, with a diameter of thirty three

A TIDE MILL, OPERATED BY MEANS OF AN UNDERSHOT WHEEL TURNED BY WATER FLOWING THROUGH A SLUICEWAY FROM A BASIN FILLED BY THE TIDE.

and a half feet at its broad edge, narrowing down to fifteen feet at the inner opening. It is mounted on a steel frame strong enough to resist a wind of a hundred miles an hour. This mounting is necessary, in order that the axis or center may always point exactly to the sun.

The disk weighs several tons, but is moved into place in the morning with a few pounds' pressure by the hand. An indicator shows when it is exactly in focus. The position once fixed, it automatically keeps its face to the sun, being regulated by a clock, like the mounting of a great telescope. As the sun becomes concentrated upon the boiler there arises, first, a vapor like the morning dew; then the heat begins to quiver within the magic circle and along the black water tube. In an hour there is a jet of steam, which is led into the compound engine and begins to turn a centrifugal pump; and the sun is "drawing water" at the rate of fourteen hundred gallons a minute. When the sun descends to the horizon, the heat no longer plays upon the boiler, and the motor stops, ready to take up its task on the coming day.

Many people who see this machine at work ask what makes it go. They seem absolutely unable to understand the idea, simple as it is. Those who do comprehend fail to appreciate the enormous power at work. Thrust a piece of copper into the focus and it will melt directly. Let the rays fall upon a piece of wood, and the flames will shoot up as by magic. Were a man to climb into the circle, he would be burned to a crisp in a few seconds. Think of the possibilities of such a machine to the writer of the future melodrama!

The Pasadena motor is the result of numerous experiments by some Boston capitalists. They built a silver reflector at enormous cost, only to abandon it. They built a machine modeled after Ericsson's, but it failed to do the work. They built a third machine at Longwood, and a fourth was set up at Denver. Now comes the Pasadena model, and with it success. Not that it is the best that can be made, for already inventors are suggesting improvements; but it actually does work, and does it well and cheaply. Better and larger machines will undoubtedly follow.

It is safe to say that, with even the present developments, the wheels of the world would not stop should every pound of her coal have been consumed.